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Validity of Clinical Color Vision Tests for Air Traffic Control Specialists

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16. Abstract

An experiment on the relationship between aeromedical color vision screening test performance and performance on color-dependent tasks of Air Traffic Control Specialists was replicated to expand the data base supporting the job-related validity of the screening tests. The original experiment (Mertens, 1990; n=108), and the replication (n=136) involved a total of 121 normal trichromats, 31 simple and 44 extreme anamalous trichromats, and 48 dichromats; both protans and deutans were included. The simulations of ATCS color tasks which served as validation criteria were flight progress strips (en route centers), aircraft lights and the Aviation Signal Light indicator (ATC terminal operations), and color weather radar (flight service station and en route center facilities). The validities (Kappa) of aeromedical screening tests ranged from 0.44 to 0.91 for prediction of error-free performance on all color dependent tasks. The aeromedical screening tests were generally acceptable in terms of selecting individuals who did not make errors, but several tests had high false alarm rates. The high job-related validity of several aeromedical color vision tests was confirmed.

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VALIDITY OF CLINICAL COLOR VISION TESTS FOR AIR TRAFFIC CONTROL SPECIALISTS

INTRODUCTION

The requirement for accurate color discrimination ability has been established (U.S. Government, Office of Personnel Management) for Air Traffic Control Specialists (ATCSs). This is necessary because of color-coding of critical information for several tasks at en route centers, terminal air traffic control (ATC) facilities, and flight service stations (FSSs) of the Federal Aviation Administration. Those tasks were identified in ATCS job analyses and field studies (Lahey, Veres, Kuyk, Clark, and Smith, 1984a, 1984b) and were listed by Mertens and Milburn (1992). Four of those tasks involve color coding as a primary, non-redundant cue. Those tasks include identification and discrimination of color in reading flight progress strips, identifying aircraft and their direction of movement from navigation lights at night, use of the Aviation Signal Light to direct aircraft with radio failure, and use of color weather radar at FSSs.

Therefore, the safety factor associated with air traffic control work necessitates accurate color identification. Errors in color identification or discrimination in these tasks have the potential of placing pilots, passengers, and their aircraft in danger. Because the need for accurate color vision has been established and is supported by research findings (Adams and Tague, 1985; Kuyk, et al., 1986, 1987; Mertens, 1990; Mertens and Milburn, 1992), the task of verifying that the ATCS applicant possesses that ability becomes a primary pre-employment concern.

Currently, the FAA accepts several clinical color vision tests for use in testing ATCS applicants (see Table 1). Those tests were intended to identify individuals with normal color vision. Mertens (1990) performed a study to validate all FAA-accepted clinical color vision tests using simulations of the four above-mentioned ATCS tasks from ATC and FSS facilities tasks that involve non-redundant color coding. Mertens studied 37 normal trichromats and 71 individuals with red-green color vision deficiency of varying type and degree. The validities of several tests were in the vicinity of 0.90 for prediction of error-free performance in ATCS color tasks, but several tests had undesirably high false alarm rates.

The present research replicated part of Mertens' (1990) study for the purpose of increasing the sample size in all color vision diagnostic categories to provide greater confidence in conclusions drawn from these analyses of color vision test validity. Data from the earlier and present studies were combined for the present analysis.

METHODS

Subjects.

The prior experiment by Mertens (1990; n=108), and the present study (n=136) involved a total of 244 subjects, including 121 normal trichromats (normal color vision), and 123 individuals with red-green color vision deficiencies of varying magnitude and of both protan (red weak) and deutan (green weak) types of deficiencies. Complete information concerning age of subjects and the distribution of males and females in each study, and color vision classifications of subjects, is presented in the report of a companion study (Mertens and Milburn, 1992). The companion study involved the same subjects and testing sessions, but was performed both to expand the data base supporting color vision requirements for ATCSs, and to more sharply define the relationship between type and degree of color vision deficiency and accurate performance of ATCS color tasks.

All subjects had at least 20/30 visual acuity in both near and distant vision, as measured by the Titmus Vision Tester or the Bausch and Lomb Orthorater vision tester. Subjects were recruited through advertisements in newsletters at Tinker Air Force Base, area colleges and universities, and through local newspapers of the Oklahoma City (OK) metropolitan area. All subjects were paid an hourly wage.

Diagnostic Color Vision Tests.

The procedure used for classification of deficiencies involved the Nagel Type I anomaloscope to classify individuals with red-green color vision deficiency, and other tests to detect and diagnose the rare blue-yellow deficiencies that the Nagel anomaloscope does not detect. None of the latter were found. A detailed descrip-

tion of diagnostic methods is found in Mertens and Milburn (1992).

ATCS Color Tasks Serving as Validation Criteria.

Flight Progress Strip (FPS) Test. The FPS test was similar to tests used in previous research by Adams and Tague (1985). It required identification of colors in color-coded computer printing or handwriting on FPSs as used at en route centers. Subjects responded by verbally identifying the color of computer printing (103 items) and handwriting (76 items) as red or black (blue). Since blue may be used instead of black, a small number of blue items were included. FPS materials were obtained from Ft. Worth, Texas; en route center and representative samples were selected. There was no time limit for responding and performance was assessed in terms of number of errors and pass-fail; the failure criterion was any error. The incident illumination level was 59 lux, an average workstation illumination measured at the Ft. Worth en route center.

Flight Progress Strip Test-Low Illumination (FPS-L) and -Normal Illumination (FPS-N). These tests compare the effects of low illumination with normal illumination. A subset of 38 of the hand-written items from the above FPS test were presented a second time under a lower, 14 lux incident illumination level. In subsequent discussion, data that concern testing with this subset of FPS test items at the normal 59 lux illumination level are referred to as the FPS-N test. The low illumination level for the FPS-L test was selected to be marginal for normals based on preliminary measurements, but was slightly higher than the lowest level (8.4 lux) found at an en route center and reported by Adams and Tague (1985). There was no time limit for responding, and performance was assessed in terms of total errors and pass-fail; the failure criterion was any error.

Aircraft Lights Test (ALT). Ten pairs of lights simulating aircraft navigation lights were projected onto a white screen positioned at eye level in a nearly dark room. The subject was seated at a viewing distance of 20 ft from the target. The ambient illumination of the screen was 1.07 lux, the recommended maximum level for interior incident illumination of tower cab windows (Illumination Engineering Society, 1972). Kodak Wratten Filters 26 and 58 were mounted over small holes in slides to simulate red and green aircraft navigation lights. White navigation lights were simulated by using no filter. Intensity of the lights was varied with neutral density Wratten filters to ensure that color could not be associated with brightness. Colors of simulated aircraft lights had the following approximate CIE 1931 chromaticity coordinates: red, x=.693, y=.307; green, x=.269, y=.683; and white, x=.460, y=.417. Although this task was similar to the aircraft lights test of Adams and Tague (1985) in terms of target colors, the angular subtense of simulated aircraft light was smaller, 1.4 min arc, and the two lights of each pair were separated vertically by 21 min of arc. The target colors met current standards of the International Civil Aviation Organization (1988) for aircraft navigation light colors. The criterion for failure of this test was any error.

Aviation Signal Light (ASL) Test. The subject identified signal colors as reflected in the indicator (bezel) on top of an ASL. Six signals were observed as the subject sighted the ASL out of a third-floor, north window at the sky. The signals were regulated by an experimenter with controls shielded from the subject's view. Signals were of 5-s duration, and intervals between signals were 3 min. The ASL signal colors (red, green, and white) were presented randomly, with the restriction that each color was presented at least once during the six trials. This test was administered between the hours of 10:00 am and 3:00 pm with sky conditions varying from clear to heavily overcast. Any error constituted failure of the task.

Color Weather Radar Test - Large Targets (Radar-L). This test involved identifying seven colors, including the six colors of the FAA weather radar color code, which represent six different levels of precipitation, and black, representing no precipitation. The weather radar color code involves two shades each of red, yellow, and green. The characteristics of display colors, 1931 CIE chromaticity coordinates x, y, and luminance (L=candelas per square meter) are presented in the companion paper (Mertens and Milburn, 1992). The display color measurements were made with the same ambient illumination (118 lux) that was present during testing. The display colors and the 118 lux ambient illumination level were similar to measurements obtained at the FSS in McAlester, Oklahoma. The display was viewed by the subject at a distance of 71 cm. On each trial, a bar showing the colors of all six precipitation levels (in order

of magnitude) was located 7 deg above the center of the target. Each color segment in the bar subtended 0.5 deg vertically and 1.3 deg horizontally. The radar task required identifying the color of a 0.5 deg square target that was located at the center of a 4 deg square background. All possible combinations of target/background colors were used to discourage guessing, but only the 12 combinations most commonly found in radar, and which represent adjacent precipitation levels, were used for test trials and scored. There was no time limit for responding. Following a response, there was a 5-s delay before presentation of the next stimulus. Any error caused failure of the test. Total errors were also counted.

Color Weather Radar Test-Small Targets (Radar-S). This task was identical to Radar-L, with the exception that targets were smaller, subtending approximately 0.1 deg. The 0.5 deg target size of Radar-L was chosen to be sufficiently large so that color discrimination of individuals with normal color vision would not be adversely affected by target size. With the 0.1 deg size, somewhat decreased discrimination ability for colors on the red-green axis was expected. Discussions with Flight Service Specialists and meteorologists working at FAA facilities indicated that identification of the color of very small weather radar targets is important. The 0.1 deg target size was similar to the size of small targets seen on several weather radar displays at FSS and en route centers and is approximately 4 x 4 pixels in size on the Tektronix 4125 color graphics work station used to present the weather radar tasks. The monitor, 38.3 cm on the diagonal, had a resolution of 1280 x 1024 pixels. Lahey, et al. (1984a) also selected 0.1 deg as a small target size relevant to ATCS color tasks.

Aeromedical Color Vision Screening Tests.

All aeromedical color vision screening tests currently known to be in use by Aviation Medical Examiners (AMEs) for the initial medical examinations of ATCSs and pilots were evaluated. These tests can be grouped into three categories: 1) nine pseudoisochromatic plate tests, 2) three lantern tests, and 3) four multifunction vision testers; they are listed in Table 1 with their First Class disposition criteria (FAA Aviation Medical Examiner's Guide 1980). The Class I criteria are intended to select normal trichromats.

Pseudoisochromatic Plate Tests. The 14-, 16-, and 24-plate Ishihara tests all involve subsets of plates from the 38-plate Ishihara test. Only the 14-plate and 38-plate Ishihara tests were administered. Scores for the 16- and 24-plate tests were computed based on responses to appropriate subsets of plates of the 38-plate test. It is assumed that any differences between the plates of this simulation and the actual plates of those tests are minor and would be similar to different printings of the same plate. The Dvorine, Richmond, and AOC-18 plate, -15 plate and -HRR were also given. The full test names are given on Table 1. A Macbeth Easel Lamp was used to illuminate all plate tests, with all other lighting extinguished during testing. All screening tests were administered according to manufacturer's directions.

Lantern Tests. The Farnsworth Lantern test was developed by the U.S. Navy and is currently used for aeromedical screening by both the Navy and the U.S. Air Force. The Farnsworth Lantern test was given in a normally lighted room, according to the manufacturer's directions, with the subject positioned 8 ft in front of the lantern. The U.S. Air Force's School of Aviation Medicine Color Threshold Tester (SAM-CTT) was given, but those data are not included in this report since use of the SAM-CTT by the U.S. Air Force has recently been discontinued. The Edridge-Green Lantern test was not given because its use is rare and there are no known standard procedures for test administration.

Multifunction Vision Testers. Several multifunction vision instruments include color vision tests that are accepted by the FAA; all involve photographic reproductions, either prints or positive transparencies, of pseudoisochromatic plates. The Titmus, Titmus II, and OPTEC 2000 vision testers all involve positive color transparencies, which are reproductions of Ishihara test plates. Each of these tests was given in a different testing room at a different time and in a dimly-lit room. The Keystone test involves photographs of six plates, which were developed specifically for that test. The Keystone test was illuminated using only that instrument's lamp; room lights were turned off.

Procedure.

The simulated ATCS color tasks, diagnostic tests, and clinical color vision tests were administered at four testing stations, each supervised by a trained laboratory

technician. All anomaloscope testing was performed by the senior researcher. The tests at each station took approximately 45 min to administer. The testing of each subject was performed in two, 2-hour sessions separated by a 1-hour lunch break or given on successive days. Within each session, the two 45-min testing periods were separated by a 15-min break. Since the OPTEC 2000, Titmus, and Titmus II involved reproductions of the same set of six Ishihara plates, each of those tests was placed at a different testing station to separate them in time and by administrations of several other tests.

RESULTS AND DISCUSSION

Relation of ATCS Color Task Performance to Clinical Color Vision Tests.

The validities of color vision tests currently in use for aeromedical screening of ATCS personnel were evaluated regarding prediction of pass/fail performance on the ATCS color tasks. The validity of screening tests was also compared with the validity of anomaloscope classification as a predictor of performance. Cohen's (1960) Kappa (K), an index of agreement, was used to assess the validity of the color vision screening tests, as recommended by the NAS-NRC Committee on Vision (1981). The index can be interpreted as the precentage agreement between test and criterion variable, with correction for chance. The four ATCS color tasks involving normal and difficult color task situations were used as the criteria for assessing the screening tests. That is, the four ATCS color tasks were used as samples of critical ATCS work behaviors against which the color vision tests were validated as personnel selection criteria. These data on validity are given in Tables 3, 4, 5, 6, 7, and 8. Validities given in Table 2 involve a composite pass/fail score for the three ATC tasks, the FPS, ALT, and ASL tasks; this overall score is named the ATC Tasks score. Validities given in Table 3 involve an overall composite score for the same three ATC tasks plus the FSS-related Radar-L task; this overall score is named the ATC/FSS Tasks score. Both composite scores involved only normal conditions and did not involve the low illumination condition of the FPS-L task or the small radar target size of the Radar-S task. Failure of any test among the three ATC tasks performed under normal conditions caused failure on the ATC Tasks score. Failure of any test among those three ATC tasks, or the Radar-L task, caused failure on the ATC/FSS Tasks score. In addition to those simulations, which represent common conditions in tasks, validities are also given for prediction of performance in the FPS task under low illumination (FPS-L) and in the Radar task with smaller target sizes (Radar-S). The latter are less common conditions, but still within the range of conditions that could occur in those tasks. In addition to validities, each table lists the miss and false alarm rates for each test. Miss rate is the probability of passing the clinical test, given failure on the criterion ATC or FSS color task. The false alarm rate is the probability of failing the screening test, given passing on the criterion task. Miss and false alarm rates are sometimes alternatively referred to as false negative rate and false positive rate, respectively.

A diagnosis of normal trichromat, as defined in Mertens and Milburn (1992), was required for "passing" the anomaloscope test in the present analysis. Passing the anomaloscope was highly related to performance on the ATC Tasks score (K=.93), the ATC/FSS Tasks score (K=.89), the FPS Task (K=.88), and the ALT (K=.88), as shown in Tables 2, 3, 4, and 6. Several color vision plate tests had comparably high validities in predicting those scores. The plate tests with high validity were those known to have high validity for screening normal trichromats. The validities of the anomaloscope test were lower in prediction of performance on the Radar-L and ASL task (see Tables 7 and 8), primarily due to higher false positive rates. As shown by Mertens and Milburn (1992), more simple and extreme anomalous trichromats were able to pass those tasks than the other ATCS tasks studied. The highest validity obtained for prediction of performance on the Radar-L (K=.81) and ASL (K=.76) tasks was with the Farnsworth Lantern. That test is known to pass some individuals diagnosed as simple anomalous by the anomaloscope (Steen, et al., 1974). The FPS-L and Radar-S simulated observation conditions were more difficult, as expected, than the corresponding FPS-N and Radar-L tasks (see Tables 5 and 8, respectively). The greater difficulty in the FPS-L and Radar-S tasks was reflected by a decrease in the false alarm rate and an increase in the miss rate for all clinical tests, compared to corresponding rates when performance on FPS-N and Radar-L tasks were predicted.

The high validities of some clinical tests for predicting performance in the FPS and ALT tasks indicate the requirement for a high level of color vision ability in normal performance of those tasks. Almost all FAA-accepted clinical color vision tests for the Class I standard have low miss rates for the FPS and ALT tasks (see Tables 2, 4, and 6), but false alarm rates vary widely. An anomaloscope diagnosis of normal trichromat, or a passing score on any one of several FAA-accepted color vision plate tests designed to select normal trichromats, were the best predictors of error-free performance on simulated ATCS color tasks.

CONCLUSIONS

Accurate color vision is essential for performance of certain critical ATCS tasks. The collective data from both the original and the replication studies show that occurrence of error on simulated ATCS color tasks was rare among persons passing the recommended color vision screening tests, and common among persons failing those tests. The validities of the best clinical color vision tests for prediction of performance on the Flight Progress Strips, Aircraft Lights tasks, and composite scores, are very high, in the vicinity of 0.90 or above. Those validity levels are comparable to the validity of the same clinical tests when used for differentiating between normal trichromats and color vision deficients, as reported by the NAS-NRC Committee on Vision (1981).

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APPENDIX A

Table 1

Color Vision Tests Accepted by the FAA for Airmen Certification

ACCEPTED TESTS	FULL TEST NAME	ATCS FAILURE CRITERIA (Class I Certification)
Pseudoisochromatic Plate Tests		
1. AOC (18-Plate)	American Optical Company Pseudoisochromatic Plates - 1940 Edition.	4 or more errors, plates 1-18
2. AOC (15-Plate)	American Optical Company Pseudoisochromatic Plates - 1965 Edition	5 or more errors, plates 1-15
3. Richmond	Richmond Pseudo-Isochromatic [sic] Plates for Testing Color Perception	5 or more errors, plates 1-15
4. AOC-HRR	American Optical - Hardy, Rand, Rittler Pseudoisochromatic Plates - Second Edition	any error on plates 1-6
5. Dvorine (2nd Ed.)	Dvorine Pseudo-Isochromatic [sic] Plates - Second Edition	3 or more errors, plates 1-15
Ishihara's Tests for Color-Blindness		
6. Ishihara (14-Plate)	Concise Edition	2 or more errors, plates 1-11
7. Ishihara (16-Plate)	16 Plates Edition	2 or more errors, plates 1-8
8. Ishihara (24-Plate)	24 Plates Edition	3 or more errors, plates 1-15
9. Ishihara (38-Plate)	38 Plates Edition	4 or more errors, plates 1-21
Lantern Tests		
10. Edridge-Green Lantern	Edridge-Green Colour Perception Lantern	not studied, rarely used
11. Farnsworth Lantern	Farnsworth Lantern	avg. of more than 1 error per series
12. SAMCTT	School of Aviation Medicine Color Threshold Tester	not studied, no longer used by USAF
Multifunction Vision Testers		
13. Keystone Orthoscope/ Telebinocular	Keystone Telebinocular Test Unit, Aeromedical Model	any error
14. OPTEC 2000	OPTEC 2000 Vision Tester, Aeromedical Model	any error
15. Titmus	Titmus Vision Tester	any error
16. Titmus II	Titmus II Vision Tester	any error

Table 2

Validity of Color Vision Selection Tests for Prediction of Composite Scores on Three ATC Tasks (FPS, ASL, and ALT)

TEST	ERROR RATE (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	1.7	5.6	.93
FAA-Accepted Tests (Class I)			
AOC (15-Plate)	1.7	11.1	.87
Richmond	1.7	7.9	.90
AOC (18-Plate)	2.5	15.1	.82
AOC-HRR	1.7	7.1	.91
Ishihara (14-Plate)	1.7	4.8	.93
Ishihara (16-Plate)	1.7	5.6	.93
Ishihara (24-Plate)	1.7	3.2	.95
Ishihara (38-Plate)	1.7	3.2	.95
Dvorine	1.7	5.6	.93
Titmus Tester	1.7	54.0	.44
Titmus II Tester	0.8	48.4	.50
OPTEC 2000	2.5	30.2	.67
Keystone	1.7	9.5	.89
Farnsworth Lantern	9.4	1.6	.89

Table 3

Validity of Color Vision Selection Tests for Prediction of Overall ATC/FSS Task Performance (Fail on Any Task Under Normal Conditions)

TEST	ERROR RATE (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	6.4	5.0	.89
FAA-Accepted Tests (Class I)			
AOC (15-Plate)	5.6	10.1	.84
Richmond	6.4	7.6	.86
AOC (18-Plate)	5.6	13.4	.81
AOC-HRR	6.4	6.7	.87
Ishihara (14-Plate)	6.4	4.2	.89
Ishihara (16-Plate)	6.4	5.0	.89
Ishihara (24-Plate)	6.4	2.5	.91
Ishihara (38-Plate)	6.4	2.5	.91
Dvorine	6.4	5.0	.89
Titmus Tester	3.2	52.9	.44
Titmus II Tester	2.4	47.1	.51
OPTEC 2000	6.4	30.3	.64
Keystone	6.4	9.2	.84
Farnsworth Lantern	13.7	0.8	.85

Table 4

Validity of Aeromedical Color Vision Screening Tests for Prediction of Performance on the FPS Test (59 lux Illumination)

TEST	ERROR RATE (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	0.9	10.4	.88
FAA-Accepted Tests (Class I)			
AOC (15-Plate)	0.9	15.7	.82
Richmond	0.9	12.7	.85
AOC (18-Plate)	2.7	20.1	.76
AOC-HRR	0.9	11.9	.86
Ishihara (14-Plate)	0.9	9.7	.89
Ishihara (16-Plate)	0.9	10.4	.88
Ishihara (24-Plate)	0.9	8.2	.90
Ishihara (38-Plate)	0.9	8.2	.90
Dvorine	0.9	10.4	.88
Titmus Tester	0.9	56.0	.41
Titmus II Tester	0.9	51.5	.45
OPTEC 2000	1.8	33.6	.62
Keystone	0.9	14.2	.84
Farnsworth Lantern	8.3	6.0	.86

Table 5

Validity of Color Vision Selection Tests for Prediction of Performance on the Flight Progress Strips Subtest Given Under Both Normal (FPS-N) and Low (FPS-L) Illumination

	NORMAL ILLUM. (59 lux)			LOW ILLUM. (14 Lux)		
	Error Rate (%)			Error Rate (%)		
TEST	Miss	False Alarm	Validity (Kappa)	Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	0.0	13.6	.84	3.5	9.3	.87
FAA-Accepted Tests (Class I)						
AOC (15-Plate)	0.0	18.6	.79	2.6	14.0	.83
Richmond	0.0	15.7	.82	1.7	10.1	.88
AOC (18-Plate)	1.9	22.9	.73	4.3	18.6	.76
AOC-HRR	0.0	15.0	.83	2.6	10.1	.87
Ishihara (14-Plate)	0.0	12.9	.85	3.5	8.5	.88
Ishihara (16-Plate)	0.0	13.6	.84	2.6	8.5	.89
Ishihara (24-Plate)	0.0	11.4	.87	3.5	7.0	.89
Ishihara (38-Plate)	0.0	11.4	.87	3.5	7.0	.89
Dvorine	0.0	13.6	.84	3.5	9.3	.87
Titmus Tester	0.0	57.1	.39	0.9	54.3	.43
Titmus II Tester	0.0	52.9	.43	0.9	49.6	.48
OPTEC 2000	1.0	35.7	.60	1.7	31.0	.66
Keystone	0.0	17.1	.80	2.6	12.4	.84
Farnsworth Lantern	6.8	8.6	.84	10.5	4.7	.85

Table 6

Validity of Color Vision Selection Tests for Prediction of Performance on the Aircraft Lights Test

TEST	ERROR RATE (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	1.8	9.8	.88
FAA-Accepted Tests (Class I)			
AOC (15-Plate)	1.8	15.2	.82
Richmond	1.8	12.1	.85
AOC (18-Plate)	2.7	18.9	.77
AOC-HRR	1.8	11.4	.86
Ishihara (14-Plate)	1.8	9.1	.89
Ishihara (16-Plate)	1.8	9.8	.88
Ishihara (24-Plate)	1.8	7.6	.90
Ishihara (38-Plate)	1.8	7.6	.90
Dvorine	1.8	9.8	.88
Titmus Tester	1.8	56.1	.40
Titmus II Tester	0.9	50.8	.46
OPTEC 2000	2.7	33.3	.62
Keystone	1.8	13.6	.84
Farnsworth Lantern	8.9	4.6	.87

Table 7

Validity of Color Vision Selection Tests for Prediction of Performance on the Aviation Signal Light Indicator Test

TEST	ERROR RATE (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	0.0	24.1	.69
FAA-Accepted Tests (Class I)			
AOC (15-Plate)	0.0	28.5	.64
Richmond	0.0	25.9	.66
AOC (18-Plate)	1.2	31.6	.59
AOC-HRR	0.0	25.3	.67
Ishihara (14-Plate)	0.0	23.4	.69
Ishihara (16-Plate)	0.0	24.1	.69
Ishihara (24-Plate)	0.0	22.2	.71
Ishihara (38-Plate)	0.0	22.2	.71
Dvorine	0.0	23.4	.69
Titmus Tester	0.0	62.0	.30
Titmus II Tester	0.0	58.2	.33
OPTEC 2000	1.2	43.0	.47
Keystone	0.0	27.2	.65
Farnsworth Lantern	2.4	16.5	.76

Table 8

Validity of Color Vision Selection Tests for Prediction of Performance on Tests Radar-L and Radar-S

TEST	LARGE TARGETS Error Rate (%) Miss	False Alarm	Validity (Kappa)	SMALL TARGETS Error Rate (%) Miss	False Alarm	Validity (Kappa)
Anomaloscope (Pass Normal or Mild)	5.8	18.4	.74	23.9	5.6	.65
FAA-Accepted Tests (Class I)						
AOC (15-Plate)	4.9	22.7	.70	20.6	7.9	.67
Richmond	5.8	20.6	.71	21.3	4.5	.69
AOC (18-Plate)	3.9	24.8	.69	20.0	11.2	.65
AOC-HRR	5.8	19.9	.72	21.9	4.5	.69
Ishihara (14-Plate)	5.8	17.7	.75	23.2	3.4	.68
Ishihara (16-Plate)	5.8	18.4	.74	23.2	4.5	.67
Ishihara (24-Plate)	5.8	16.3	.76	23.9	2.2	.68
Ishihara (38-Plate)	5.8	16.3	.76	23.9	2.2	.68
Dvorine	5.8	18.4	.74	22.6	3.4	.69
Titmus Tester	1.9	58.9	.35	9.7	49.4	.44
Titmus II Tester	1.9	54.6	.40	9.7	42.7	.50
OPTEC 2000	5.8	39.7	.51	17.4	28.1	.54
Keystone	5.8	22.0	.70	20.6	5.6	.69
Farnsworth Lantern	8.7	10.0	.81	30.5	1.1	.62

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